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The attached photocopy is a true copy of the following document:

- The specification, claims, abstract and drawings as filed with the application on the filing date indicated above.

PRIORITY DOCUMENT

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Ny dansk patentansøgning
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Computer system comprising a cooling unit
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COMPUTER SYSTEM COMPRISING A COOLING UNIT

BACKGROUND OF THE INVENTION

The present invention relates to a computer system comprising at least a central processing unit (CPU) generating thermal energy when processing and said computer system also comprising a cooling system with a heat exchanger being in thermal contact with the CPU and comprising a compressor for compressing cooling refrigerant from a vaporised state to a liquid state and comprising first pipes transporting the cooling refrigerant from the compressor to the heat exchanger and second pipes leading the cooling refrigerant from the heat exchanger back to the compressor and said computer system further comprising a regulating means for at least starting and stopping the compressor.

It is known to cool the processor of a computer system in order to increase the operating frequency of the processor to a value above the value intended or expected by the producer of the processor. Whenever a processing unit of a computer system is processing, heat is generated. This reduces the working capacity of the unit, and therefore it is desirable to cool the processing unit by means of a cooling system in order to increase the processing frequency of the processor.

DESCRIPTION OF THE PRIOR ART

US 5.574.627 describes such a cooling system. The system comprises a heat exchanger being in contact with a central processing unit. The CPU is attached to a so-called motherboard. A refrigeration compressor unit such as the one used in a conventional refrigerator provides the cooling. Similar cooling unit is further described at homepage www.kryotech.com from the company Kryotech, Inc. Around the CPU and around the heat exchanger, insulation is provided. The insulation ensures that any dew that may be generated on the cool surface of the heat exchanger or on the cooled down surface of the processor is avoided. However, if dew never the less should generate on the insulation, resistive ink is provided at the outer surface of the insulation in order to heat the insulation if necessary.

This cooling system described in this patent and also the system described in www.kryotech.com have some disadvantages. Firstly, the compressor used is very bulky compared to the rest of the components of the computer system which all should be as small as possible for fulfilling the demands of small sized computers. The compressor is a conventional compressor using high voltage power supply such as 220/230 V or 110/115 V. This creates the need for extra electrical insulation and other measures for maintaining a sufficient electrical security. Also, the heat generated by the compressor will to a certain extend be conducted up through the computer itself and past the components of the computer system thereby increasing the internal temperature of the casing of the compressor.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a cooling system for a computer system where the flexibility of using the cooling system is greater than for known systems and where the risk of electrical damage or lack of electrical security is reduced so that the overall functionality of the computer system is increased.

This purpose is obtained by a computer system where the compressor is a low voltage compressor with a voltage usage below the voltage of the public electrical power distribution network.

Using the public net is obvious because the computer system itself always has the need for electrical power from the public net, so there is no reason why the compressor should not also have electrical power from the public net. However, by using a low voltage compressor certain surprising advantages are obtained compared to using conventional high voltage compressors adapted for using the voltage supply of the public electrical distribution net, although special supplementary features are needed in the computer system, which may cause disadvantages which do not occur when using high voltage compressors. However, the advantages obtained when using low voltage compressor may justify the disadvantages involved.

A first advantage of using a low voltage compressor is that it is possible to power the compressor from the electrical power supply of the computer system itself, thereby eliminating the need for a supplementary power supply. It also means that using the

computer with different networks as example 220/230 V or 110/115 V is indifferent to the compressor because the power is supplied from the power supply of the computer system. Any switch between as example 220 V and 110 V will just have to be made for the components of the computer, and the compressor neither needs to be suited for the actual voltage of the electrical distribution network nor needs to have a switch of its own for switching between different voltages of networks around the world.

A second advantage of using a low voltage computer is that it is very easy to incorporate means for regulating the capacity of the compressor. This makes it possible to individually graduate the degree of lowering the temperature and also makes it possible to adjust the capacity in response to the need for cooling. As example, when the computer system is in a standby mode or in any other way is not performing greater processing, then the need for cooling is limited as compared to situations when the processor is performing actual processing. The means for regulating the capacity of the compressor may be controlled by additional software incorporated in the computer system. The means for regulation may also be more conventional regulating means or a combination of these and software controlling.

A third advantage is that the size of a low voltage compressor may be smaller than the size of a conventional high voltage compressor. This means that the space needed for the cooling system is limited and advantageously the cooling system may be incorporated into the standard cabinet of the computer system. Also, the power consumption of a low voltage compressor is lower than that of conventional high voltage compressors, as example 50W compared to 120W. Apart from reducing the overall power consumption of the computer system, the reduced power consumption may also limit the size of certain electrical components in the compressor.

Also it is possible to incorporate the compressor into the top of the cabinet because not only the size but also the weight of the low voltage compressor may be smaller than for conventional compressors. Accordingly, there will neither be any space problem nor any stability problem of placing the compressor in the top of the cabinet. Placing the compressor in the top of the cabinet means that the heat generated when the compressor is working is not passed through the computer itself and is not passed through the components of the computer system.

In a preferred embodiment the computer system wherein the CPU and the heat exchanger are enclosed in a box, the insulation material is provided between at least the heat exchanger and the inside of the box, preferably is provided also between the CPU and the inside of the box.

The advantages of enclosing the heat exchanger and the processor in insulation are already known. However, also enclosing the insulation in a box has the advantage that the processor and the insulation are capsuled and constitute a unit of its own. Enclosing the heat exchanger and the processor together with the insulation in a box means that it is actually possible to market and sell these components as an integrated unit.

As example, if a computer already having a cooling system has to be upgraded, then it is necessary to substitute the processor. Substituting the processor may involve also substituting the heat exchanger to one with a larger cooling capacity. This can easily be done if the processor, the heat exchanger and the insulation are enclosed in a box constituting a unit. Thereby it is not necessary to dismantle the insulation and the heat exchanger, substituting the processor and afterwards assemble the heat exchanger and the insulation again.

If the box is black and perhaps is also lustreless, then the outside of the box will have the best opportunity to receive heat from the surroundings, and thereby keeping as high a temperature as possible of the box. This avoids the formation of dew on the box. The box may as a supplement be provided with a heating element in thermal contact with the outer or inner surface of the box for heating the box to further avoid the formation of dew.

However, in other situations it may only be necessary to substitute the processor, but not absolutely necessary to substitute the heat exchanger. Also in this situation it is convenient to have the processor, the heat exchanger and the insulation all enclosed in a box. It will be possible to dismantle the insulation and the heat exchanger outside of the computer system and thereafter substituting the processor and assemble the insulation and the heat exchanger again also outside the computer and finally placing the box in the computer.

Thus the overall flexibility of the computer system according to the invention is highly increased by the combination of the above mentioned features. This is important in

especially this field of business, where the technical development is extremely fast and therefore fosters the need of a possibility to substitute one or more components with new components, but also a need for a uniform product that may be used all around the world because most computer systems are universal. Thus using a low voltage compressor makes the computer system according to the invention universal, while using components that are not physically bonded together and which are enclosed in a box constituting a unit at the same time increases the flexibility by facilitating easy substitution of the components.

BRIEF DESCRIPTION OF THE INVENTION

The invention will now be described in detail with reference to the accompanying drawing, where

fig. 1 shows an embodiment of the invention enclosed in a box that is mounted in a computer system,

fig. 2 shows a cooling system mounted in the top of a computer cabinet and comprising a compressor and an external heat exchanger,

fig. 3 shows the box with the embodiment of the invention enclosed and provided with a heating element around the exterior of the box,

fig. 4 shows different components of the box enclosing part of the cooling system according to the invention and

fig. 5 - fig. 13 show different steps in assembling the components inside the box and in assembling the box itself.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 is a photograph showing a motherboard 1 inside a computer cabinet 2. At the motherboard 1 a black box 3 is shown. The box 3 encloses the central processing unit (CPU) (not shown) of the computer system. Apart from enclosing the CPU, the box also encloses a heat exchanger (not shown) being in thermal contact with the CPU. The box is kept in place by means of the connection pins from the printed circuit board at which the CPU is placed (see fig. 6), said connection pins being inserted in the appropriate slots in the motherboard. A hose 4 extends from the box 3 to a compressor (see fig. 2). The hose 4 contains metal piping for conducting coolant liquid from the compressor to the heat

exchanger in the box and for returning the vaporised coolant from the heat exchanger in the box to the compressor.

Fig. 2 is a photograph showing the part of the cooling unit being outside the box (see fig. 1), i.e. all of the cooling units except the heat exchanger being in thermal contact with the CPU. The cooling unit comprises a compressor 5. The compressor 5 is a special low voltage compressor, preferably a 12V compressor. A metal piping (not shown) is leading through the hose 4 from the compressor 5 to the heat exchanger in the box (see fig. 1), and an other metal piping 6 is leading back to the compressor 5. Before being led into the compressor 5 the vaporised coolant is led past an exterior heat exchanger 7 for cooling down the vaporised coolant returning from the heat exchanger being in contact with the CPU.

The cooling unit is placed inside the standard cabinet 2 of a computer system, and is placed in the top of the cabinet. This way it is assured that the heat from the compressor 5 when in duty and the heat from the exterior heat exchanger 7 shown is not led past any of the other components in the computer system causing these to be further heated. The duty periods of the compressor are regulated in accordance with the demand for cooling. The regulation may be either an on/off switching of the compressor, or may be a stepwise or may even be an infinitely adjusting of the rotational speed of the compressor. Regulation of the rotational speed may be controlled by software programs installed in the computer system. Alternatively the regulation of the rotational speed may be controlled by hardware.

Fig. 3 is a photograph showing the box 3 provided with a heating element 8 around the outer surface of the box. The heating element 8 consists of a foil 9 provided with metallic wires 10 attached to the foil. Electric wires 11 lead to the heating element 8 for providing electrical power to the wires 10 on the foil 9 in order to heat the outer surface of the box 3. By heating the outer surface of the box the risk of dew forming on the outer surface is avoided. Dew may occur because of the cold heat exchanger inside the box although insulation is provided between the heat exchanger and the casing of the box.

Apart from being provided with a heating element 8 the box is preferably black and provided with a lustreless surface. Both of these features further minimises the risk of dew occurring because the casing of the box, when being black and lustreless, receives as

much heat in the form of radiation heat both from the heating element wrapped around the outer surface of the box but also from the surroundings. Alternatively, the box may have other appearances in relation to colour and surface if the problem of dew occurring is not that great a problem. As example, if it is a greater problem that heat from the surroundings limits the capacity of the heating element inside the box because of heat penetrating through the box and through the insulation then it will be more favourable to have a white box with a shiny surface in order to reject as much of the heating radiating from the surroundings inside the computer system.

Fig. 4 is a photograph showing the different components of the box shown in fig. 1 and fig. 3. The box 3 consists of a casing consisting of two halves 12,13 (see fig. 5 and fig. 13) and of insulation 14-17 for being placed inside the casing and for surrounding the CPU and the heat exchanger thereby forming a thermal barrier between these components and the casing of the box. Furthermore the box comprises bolts 18,19 and nuts 20 for holding together of the two parts which constitutes the casing (see the subsequent figures). The box also comprises a plate 21 for holding the heat exchanger in a firm physical and thereby firm thermal contact with the CPU. Lastly, as an option, the box comprises the heating element 8 in the form of the foil with wires (see fig. 3) for wrapping around the outer surface of the casing.

Fig. 5 - fig. 13 are photographs showing assembling of the box and of the CPU and the heat exchanger inside the box. Fig. 5 shows a first half part 12 of the casing into which a first layer 14 of insulation is placed. In the right side upper side 22 of the casing an opening 23 is provided for insertion of the tube 4 and the piping into the box 3. The part 12 of the casing and the insulation 14 are provided with holes 24 for accommodating the insertion of the bolts 19 through the insulation 14 and through the box 3. In the bottom 25 of the casing a slot (not shown) is provided through which the connecting pins of the print circuit board can be introduced (see fig. 7).

Fig. 6 shows a print circuit board 26 on which a central processing unit (CPU) 27 is placed. Also other electrical components are placed on the board 26. The board 26 is provided with connection pins 28 along the lower edge of the board. The pins 28 are intended for insertion into corresponding slots in the motherboard (see fig. 1) of the computer system. Bolts 18 are attached to the print circuit board 26. The bolts 18 are for fastening of the plate 21 for keeping the heat exchanger in place in relation to the

insulation and the casing of the box (see fig. 11). The board 26 is also provided with holes 29 for accommodating the insertion of the bolts 19 through the board.

Fig. 7 shows the print board circuit 26 as shown in fig. 6 placed in the half part 12 of the casing as shown in fig. 5. The connecting pins 28 on the print circuit board 26 are inserted though the slot (not shown) in lower part 25 of the part 12 of the casing so that the pins 28 extrude outside of the casing. Thereby the box may be fixed to the motherboard of the computer system by just inserting the connecting pins of the print circuit board in the corresponding slots in the motherboard (see fig. 1).

Fig. 8 shows a first intermediate layer 15 of insulation placed on top of the print circuit board 26 (see fig.7). A rectangular opening 30 is made in the first intermediate layer 15 of insulation so that the CPU 28 is still exposed. The first intermediate layer 15 of insulation is provided with four holes (not shown) in the sides of the insulation through which the guiding bolts 18 and the bolts 19 for assembling the casing are extending.

Fig. 9 shows a second intermediate layer 16 of insulation placed above the first intermediate layer 15 shown in fig. 8. The second intermediate layer 16 is provided with a rectangular opening 31 that is bigger than the opening 30 in the first intermediate layer 15 and intended for receiving the heat exchanger (see fig. 10). The second intermediate layer 16 is provided with a groove 32 extending from the opening 31 to the one side of the layer. The groove 32 is intended for receiving piping (see fig. 10) leading to and from the heat exchanger (see fig. 10). Also, the second intermediate layer 16 of insulation is provided with four holes (not shown) in the sides of the insulation through which the fastening bolts 18 and the assembling bolts 19 for assembling the casing are extending.

Fig. 10 shows a heat exchanger 33 placed in the insulation in the casing. The heat exchanger 33 consists of a square block inside which canals (not shown) are made for the coolant to flow through the heat exchanger. The heat exchanger 33 is accommodated in the opening 31 of the second intermediate layer 16 of insulation (see fig. 9). Piping 34 leads the coolant to and from the heat exchanger 33. The piping 34 consists of an outer pipe with a larger diameter and an inner pipe with a smaller diameter. The inner pipe extends co-axially and inside the outer pipe. The tube 4 surrounding the piping 34 is shown outside the casing. The tube 4 is insulated so that the piping 34 leading between

the heat exchanger 33 and the compressor 5 (see fig. 2) is thermally insulated from the surroundings.

Fig. 11 shows the plate 21 for keeping the heat exchanger 33 in place. The plate 21 is provided with holes (not shown) through which the fastening bolts 18 and assembling bolts 19 are extending. Nuts 20 are screwed onto the bolts 18,19 so that the plate 21 is kept in place against the heat exchanger 33 thereby assuring sufficient physical and thermal contact between the heat exchanger 33 and the CPU 27. Both the fastening bolts 18 and the assembling bolts 19 and the nuts 20 are made of plastic having a poor thermal conductivity. Thereby the bolts 18,19 and the nuts 20 will not be responsible of thermal transportation of energy either heat from the surroundings to the metal plate 21 and further on to the heat exchanger 33 or cold from the heat exchanger 33 and further on to the metal plate 21 and to the surroundings.

Fig. 12 shows a final layer 17 of insulation placed above the already mounted components in the box. The final layer is provided with two holes (not shown) through which the assembling bolts 19 extend.

Fig. 13 shows a second half part 13 of the casing of the box placed above all of the components inside the box and thereby enclosing these components in the box. The second half 13 of the casing is provided with two holes (not shown) through which the assembling bolts 19 extend. Nuts 20 are screwed onto the bolts 19 for assembling the two halves 12,13 of the box. The box is now closed. The piping (not shown) extend out through the hole 23 (see fig. 5) in the upper right side of the box and is being provided with the tube 4 around it. The connecting pins 28 of the print circuit board 26 (see fig. 6) extend through the slot (not shown) in the bottom of the box.

In the embodiment shown of the computer system according to the invention different alterations may be induced without departing from the scope of protection. As mentioned, it will be possible to exclude using the heating element wrapped around the box as shown in fig. 3. It will also be possible to use low voltage compressors with other voltage needs than 12V, as example 6V, 24V or 48V. Also in stead of using electrical power from the built in power supply of the computer system it will be possible to provide a separate low voltage power supply for the compressor parallel to the built in compressor. Regulation of the rotational speed of the compressor may be adjusted between a simple on/off

switching of the compressor to a constant 24-hour rotation of the compressor and regulating the rotational speed according to the demand for cooling.

CLAIMS

1. Computer system comprising at least a processing unit such as a central processing unit (CPU) generating thermal energy when processing and said computer system also comprising a cooling system with a heat exchanger being in thermal contact with the processing unit and comprising a compressor for compressing cooling refrigerant from a vaporised state to a liquid state and comprising first pipes transporting the cooling refrigerant from the compressor to the heat exchanger and second pipes leading the cooling refrigerant from the heat exchanger back to the compressor and said computer system further comprising a regulator for at least starting and stopping the compressor and where the compressor is a low voltage compressor with a voltage usage below the voltage of the public electrical power distribution network.

2. Computer system according to claim 1, wherein the low voltage compressor is intended for voltages in the range from 6V to 48V, preferably is intended for voltages in the range from 6V to 12V, most preferably is intended for voltages of 12 V.

3. Computer system according to claim 1 or claim 2, wherein the regulating means is capable of variable regulating the rotational speed and thereby the capacity of the compressor, preferably by regulating the speed infinitely, alternatively by regulating the speed stepwise.

4. Computer system according to claim 3, wherein the regulating means is regulated by a software means controlled by the computer system, alternatively that the regulating means is regulated by hardware means preferably also controlled by the computer system, alternatively controlled by components other than those of the computer system.

5. Computer system according to any of the preceding claims, wherein the components of the cooling system is provided with means for placing the components inside a standard cabinet of the computer system, and that said means is shaped so that the means may be placed in slots inside the computer system, alternatively may be attached to boards of the computer

6. Computer system according to any of the preceding claims, wherein the compressor is supplied with electrical power from the built-in power supply of the computer, which power

supply also is intended for powering other components of the computer, such as data-processing components.

7. Computer system according to any of the preceding claims, wherein the CPU and the heat exchanger are enclosed in an insulation material and that the insulation material is provided between at least the heat exchanger and the ambient environment, preferably also between the CPU and the ambient environment.

8. Computer system according to claim 6 wherein the processing unit and the heat exchanger are enclosed in a box, that insulation material is provided between at least the heat exchanger and the inside of the box, preferably is provided also between the processing unit and the inside of the box.

9. Computer system according to any of the preceding claims, wherein a heating element is in contact with the outside of the box, alternatively is in contact with the inside of the box, where the heating element consists of resistive wires, that the wires are in contact with the insulation, alternatively are in contact with the box, and that electrical power is supplied to the resistive wires for providing a heating of the wires and to the insulation, alternatively a heating of the inside or the outside of the box.

10 Computer system according to any of the preceding claims, wherein the box is a plastic box having a thermal conductivity lower than that of metallic materials and that the box consists of at least two parts that are mutually connected by connection means and that the connection means are made of a material with thermal conductivity that is low compared to metallic materials.

11. Computer system according to any of the preceding claims, wherein the heat exchanger only is in thermal contact with the processing unit, and that the heat exchanger and the processing unit is separable so that the processing unit may be substituted and the heat exchanger may be thermally connected to a substitutive processing unit, alternatively that the heat exchanger may be substituted and the processing unit may be thermally connected to a substitutive heat exchanger.

12. Computer system according to any of the preceding claims, wherein the box is black and preferably is also lustreless, so that the box is capable as easy as possible to receive heat from the ambient environment.

13. Computer system according to any of the preceding claims, wherein the first pipe and the second pipe are led from the compressor to the heat exchanger respectively from the heat exchanger to the compressor in parallel, and that the first pipe in immediate vicinity of the heat exchanger has a smaller cross section than the second pipe, and that the first pipe when entering the heat exchanger is led into the second pipe and is led into the heat exchanger co-axially with the second pipe.

14. Computer system according to any of the preceding claims wherein the heat exchanger is made of copper and that the pipes is made of copper and that the pipes and the heat exchanger are mutually able of being disconnected.

ABSTRACT

The invention relates to a computer system incorporating a cooling unit. The cooling unit uses conventional coolant that is being led from a compressor to a heat exchanger being in thermal contact with a component in the computer system generating heat, as example a central processing unit (CPU). The compressor is a low voltage compressor although the computer system has to have high voltage electrical power from the public electricity distribution net. By using a low voltage compressor the demands for power consumption and space may be limited. Also, it is possible to power the compressor from the built-in power supply of the computer system. In a preferred embodiment the heat exchanger being in thermal contact with the CPU is enclosed in an insulated box. The box has openings for piping leading the coolant to and from the heat exchanger, and the box preferably also has a slot so that connection pins from the printed circuit board of the CPU can protrude put through the box. Thereby the box can be attached to the motherboard by means of the connection pins.

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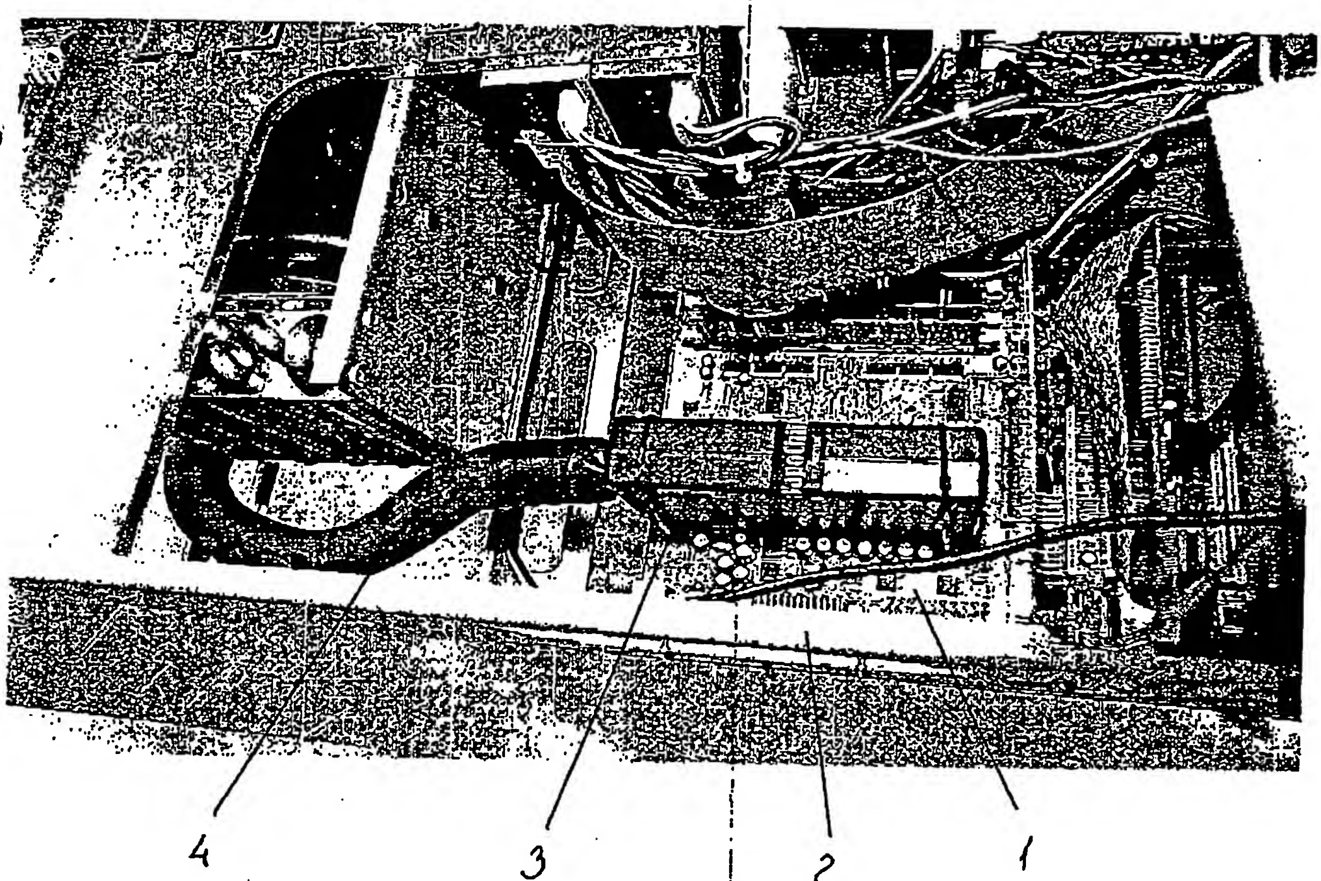

FIG. 1

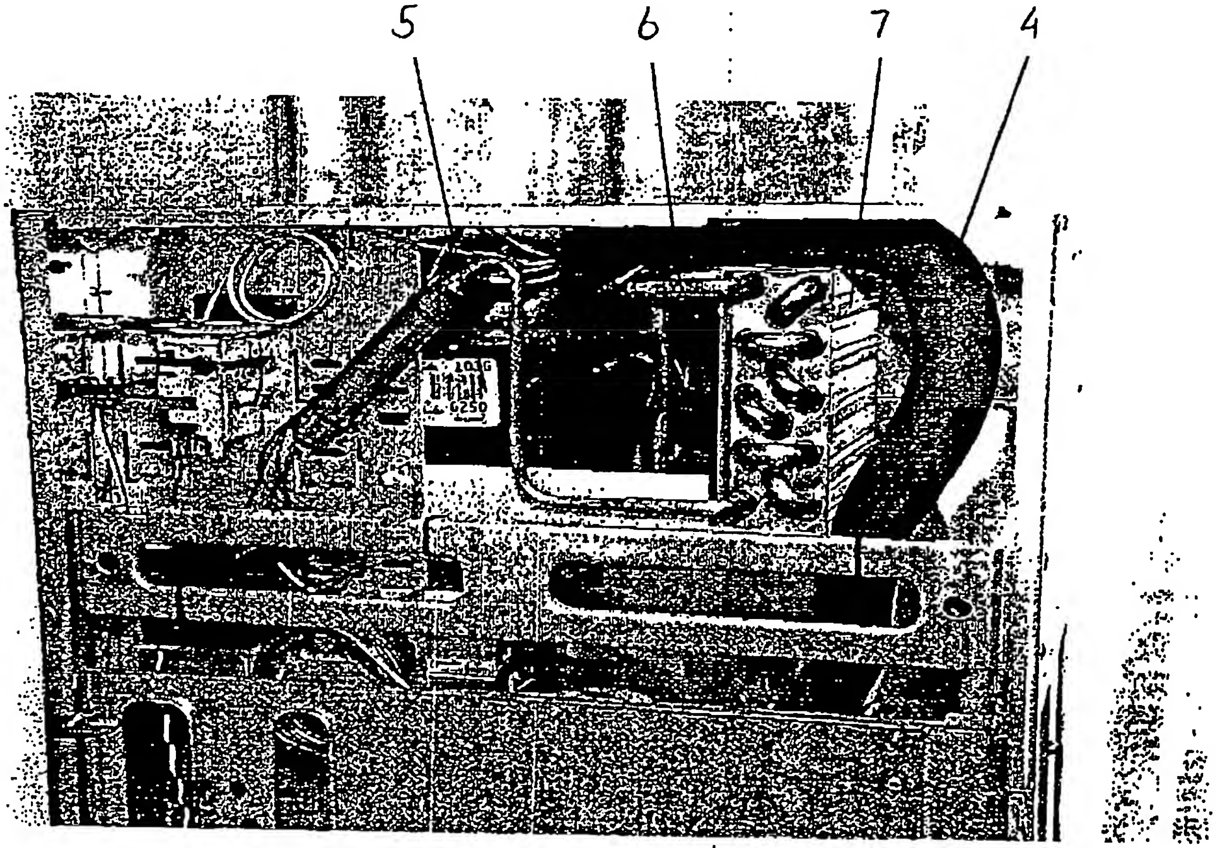

FIG. 2

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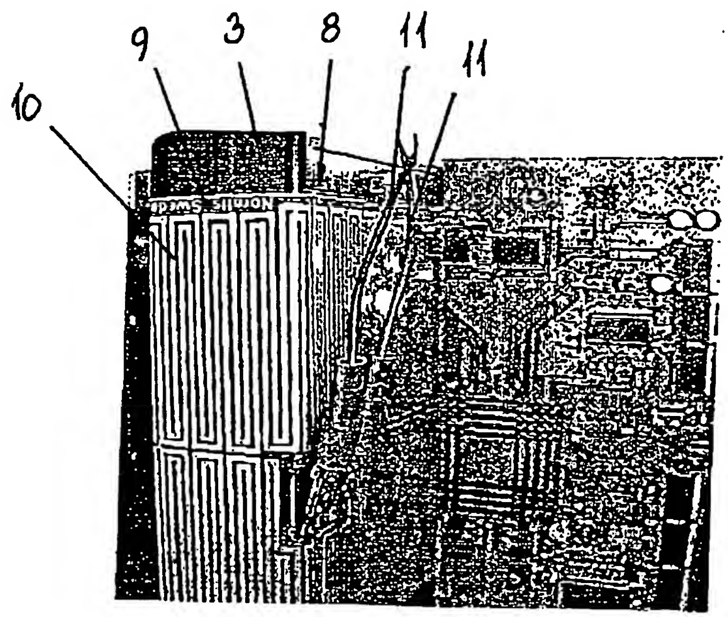

FIG. 3

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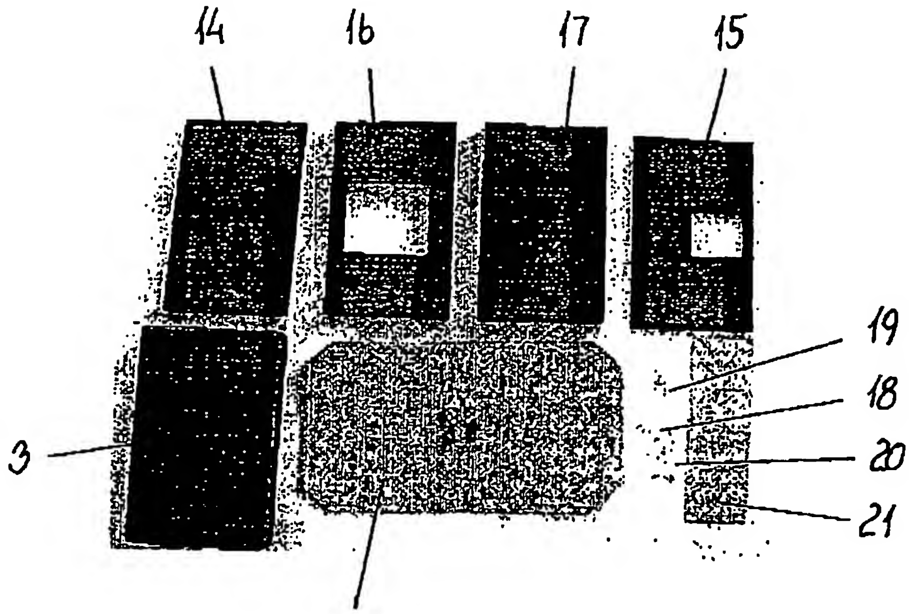

FIG. 4

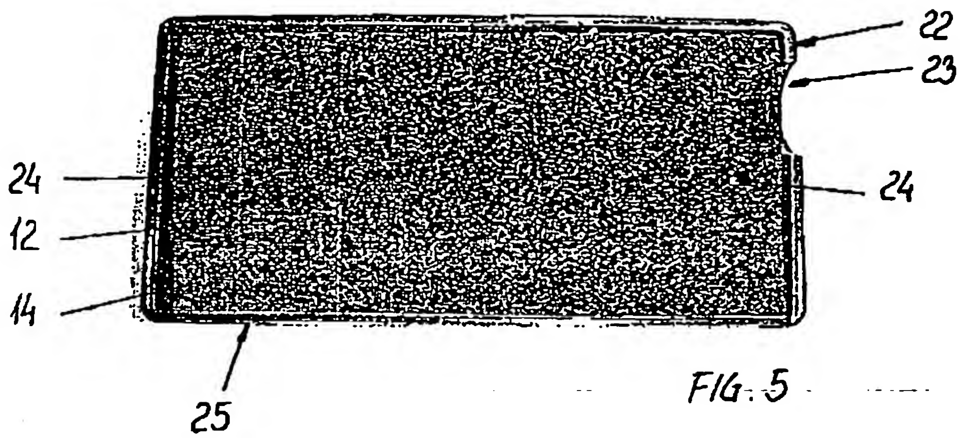

FIG. 5

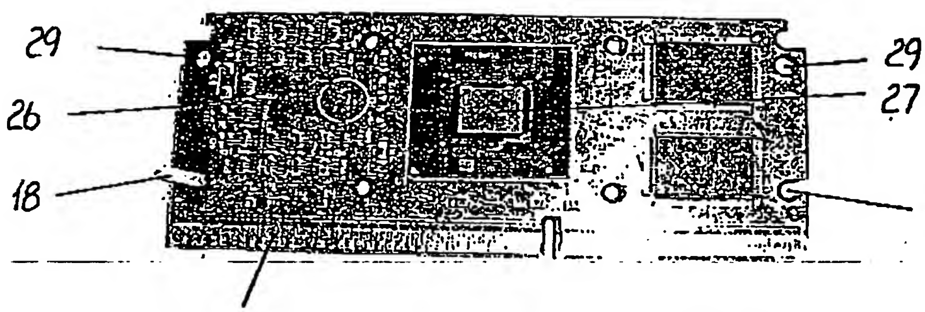

FIG. 6

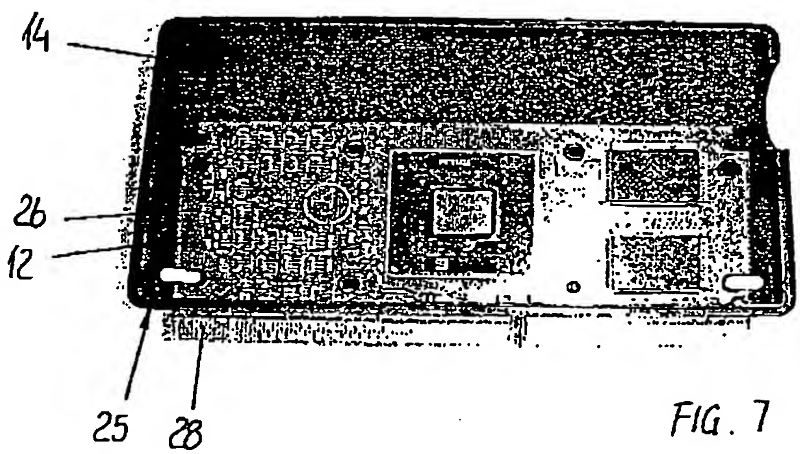

FIG. 7

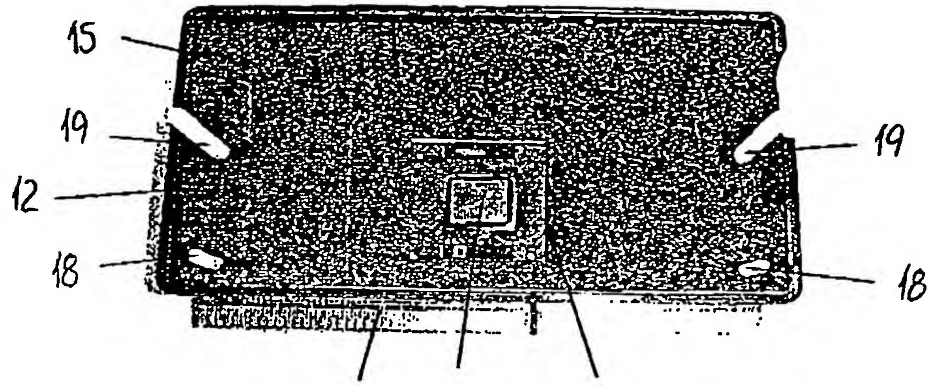

FIG. 8

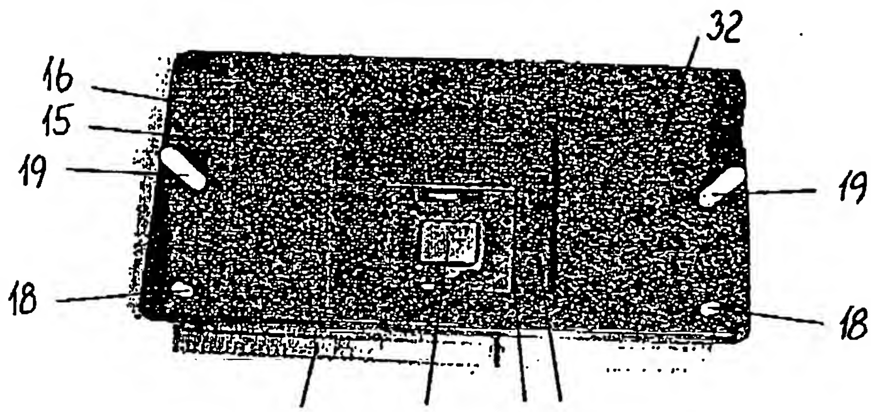

FIG. 9

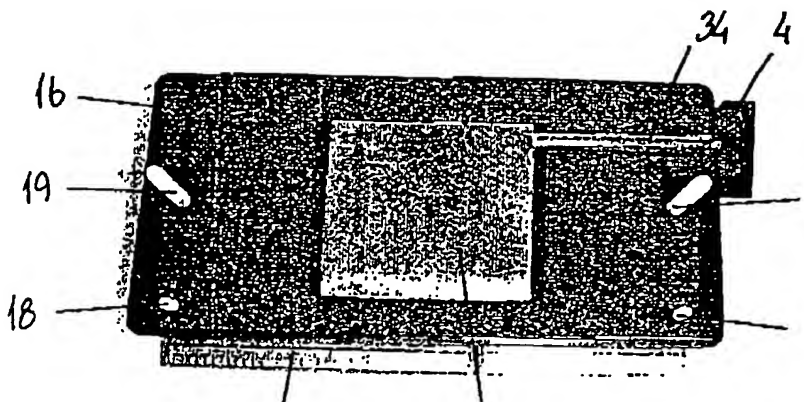

FIG. 10

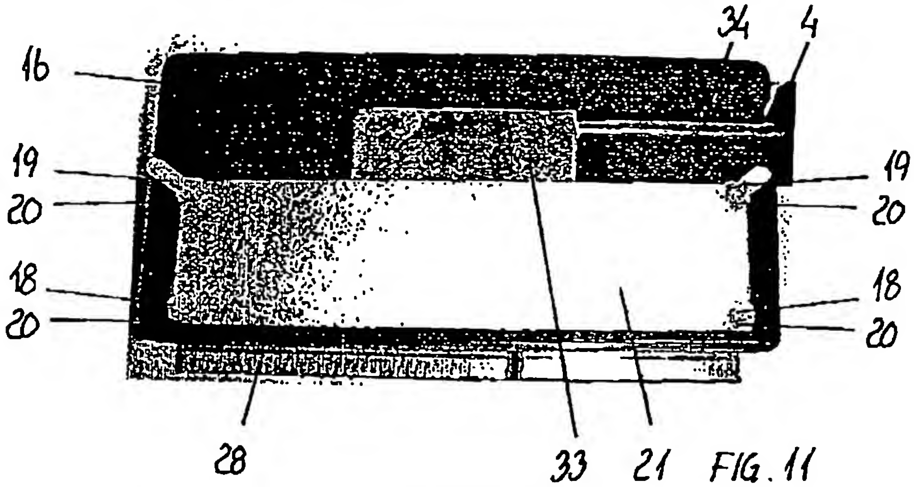

FIG. 11

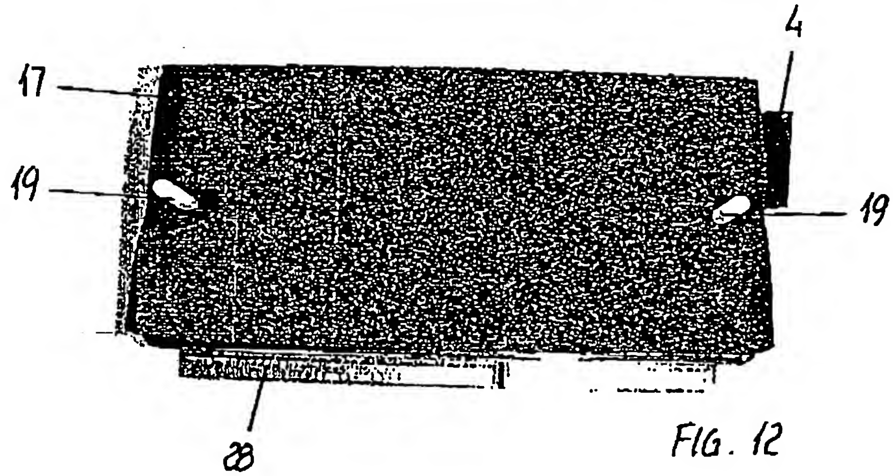

FIG. 12

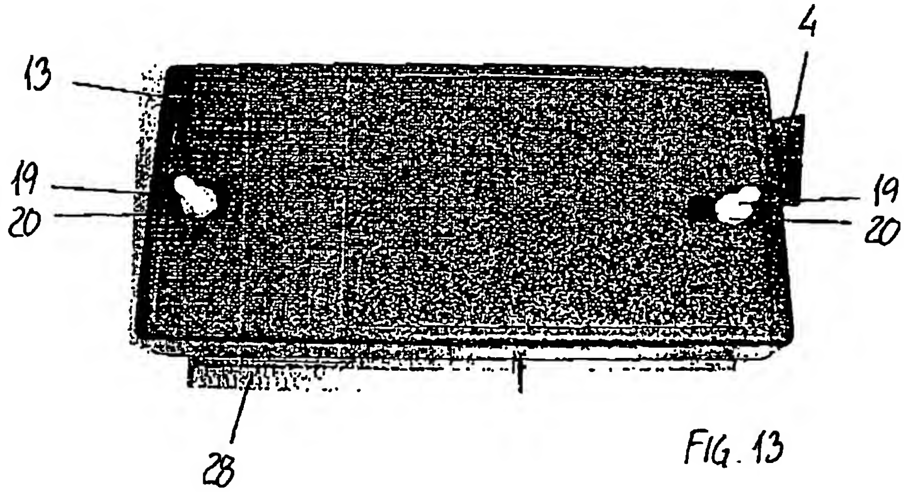

FIG. 13